# Barry Ash Pond Review
# Barry Power Generating Facility
# Mobile, Alabama

Submitted to:
**Mobile Baykeeper**

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## EXECUTIVE SUMMARY

Alabama Power operates the Barry Electric Generating Plant (the Plant) that is located approximately 30 miles north of Mobile, Alabama. The Plant uses both coal-fired and natural gas-fired power generation. The coal combustion residuals (CCR), which primarily comprise fly-ash and bottom-ash generated from burning coal, are disposed as a slurry in a large impoundment (the Barry Ash Pond) located immediately adjacent to the Plant and the Mobile River.

Burgess Environmental Ltd. (Burgess) was retained by Mobile Baykeeper to assess the Barry Ash Pond relative to 40 CFR Part 257, Subpart D - Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments (the Standards) and generally accepted practices for dam safety. Burgess' assessment is based on technical documentation that was available to Burgess at the time that this report was prepared, as well as a site visit. The findings of this assessment are presented in accordance with the primary requirements of the Standards, which include the following:

- location restrictions
- requirements for stability assessment
- flood analysis
- groundwater monitoring and corrective action
- closure planning
- record keeping and reporting

**Location Restrictions**

The Barry Ash Pond site does not comply with 3 of the 5 locations restrictions included in the Standards; the bottom of the ash pond is within 5 feet (vertically) of groundwater, it was constructed over a wetland and the area is unstable. It was also constructed into Mobile River and over Sisters Creek, a tributary of Mobile River. The base of the Barry Ash Pond is partially constructed on sandy soils that are saturated to the surface and are in hydraulic connection with the Mobile River and a regional surface aquifer. This was noted in a site assessment that was completed by ADEM (1994). It is clear that the Barry Pond was constructed over wetlands and riparian habitat that is prone to flooding. Any failure of the Barry Ash Pond would have far-reaching detrimental impacts to very important aquatic habitat (National Parks Service, 2016 and University of Alabama, 2013). The location is prone to river and wave erosion, and the dikes of the Pond are founded on soils that are likely prone to differential settlement; hence, this area is considered 'unstable' and is not appropriate for locating a CCR impoundment. These are important concerns that are specified in the U.S. EPA Standards and should be considered if the Barry Pond is to remain in use or be closed in its current location.

**Stability**

The stability assessments completed by the Plant concluded that factors of safety for the impoundment dikes complied with the requirements of the Standards by a narrow margin; however, important potential methods of failure were not included in these assessments. For example, differential settlement, erosion and potential for piping failure were not included in the stability assessment even though these are potential failure mechanisms that are clearly relevant to the Barry Ash Pond. Further, the factor of safety assessment assumed that the dikes are not potentially prone to liquefaction failure. This assumption was not supported with any facts, studies, or other analytical rigor.

**Flood Analysis**

The flood analysis completed by the Plant modelled the water levels in the Barry Ash Pond resulting from the 1 in 1,000 years, 24-hour rainfall event. The predicted water levels rose to within an inch of the top-of-dike elevation. This is not an acceptable level of safety given the potential for wave action and clogging of the Pond outfall during such events. Further, the flood analysis did not consider the potential for flooding outside of the Pond, or the potential for erosion or overtopping resulting from external flooding. The flood analysis also failed to correlate predictions with flood conditions observed during similar but smaller storms in the recent past.

**Groundwater Monitoring**

Groundwater monitoring data collected in 2016 and 2017 confirm the presence of an aquifer underlying the ash pond. ADEM (2018) has recently fined the Alabama Power Company $250,000 for groundwater pollution by arsenic, caused by the Barry Ash Pond and selenium from the nearby lined Gypsum collection basin. The groundwater report, which was issued by the Southern Company as required by the Standards, does not provide any meaningful technical analysis of the chemical impacts to groundwater and surrounding surface water by the Barry Ash Pond.

**Closure Planning**

The Barry Plant has issued a Closure Plan that contemplates initiating closure of the Barry Ash Pond in 2019 by capping the CCR in place. Given that the location of the Barry Ash Pond does not comply with 3 of the 5 location restrictions in the Standards, closure of the Pond in-place is not advised. Closure of the Barry Pond in place would require significant protective measures to combat erosion and the long-term meandering of the Mobile River, which would need to be supported by monitoring and maintenance, in perpetuity. These measures would need to be maintained into perpetuity as the Mobile River will continue to threaten the Barry Ash Pond well beyond the 30 year post closure care period required by the Standards.

**Records and Reporting**

The Plant has complied with the assessment and reporting requirements of the Standards. The Plant has relied on its owner, the Southern Company, to assess and validate the integrity of the Barry Ash

Pond. While this is consistent with the Standard, it is more typical for an organization to contract out an independent third party to assess important dam structures. The simplicity of the assessments is striking. It is more typical to include more rigorous and comprehensive analyses when assessing the integrity of such an important structure.

# 1 INTRODUCTION

## 1.1 Background

Alabama Power operates the Barry Electric Generating Plant (the Plant) that is located approximately 30 miles north of Mobile, Alabama (Figure 1-1). The Plant uses both coal-fired to natural gas-fired power generation. The coal combustion residuals (CCR), which primarily comprise fly-ash and bottom-ash generated from burning coal, are disposed as a slurry in a large impoundment (the Barry Pond) located immediately adjacent to the Mobile River and upstream of Tensaw Delta and Mobile Bay.

Mobile Baykeeper is concerned with maintaining and improving the water quality and ecosystem of Mobile Bay and by extension the upstream reaches of Mobile River. The Barry Electric Generating Plant and associated Barry Ash Pond are seen as potential risks to these water bodies. Accordingly, Mobile Baykeeper retained the services of Burgess Environmental Ltd. (Burgess) to assess the Barry Ash Pond in the context of applicable federal legislation pertaining to the management of CCR and generally accepted practices for dam safety.

## 1.2 Purpose and Scope

This report evaluates the technical documentation for the Barry Ash Pond relative to standards required by 40 CFR Part 257, Subpart D - Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments (the Standards). It also evaluates the Barry Ash Pond relative to generally acceptable engineering procedures for assessing and maintaining dam safety. The objective of this review is to evaluate the long-term stability of the Barry Pond to assist Mobile Baykeeper in understanding the risks that the Plant presents to the water quality and ecology of the Mobile River, Mobile-Tensaw Delta and Mobile Bay. The basis of information and analyses that support this review includes the following:

- a site visit to inspect the outer portions of the Barry Ash Pond and the surrounding watershed
- review of any documentation for the Barry Ash Pond that has been made available publicly by Alabama Power
- information and documentation provided by Mobile Baykeeper
- the judgment and experience of the author

## 1.3 Documents Reviewed

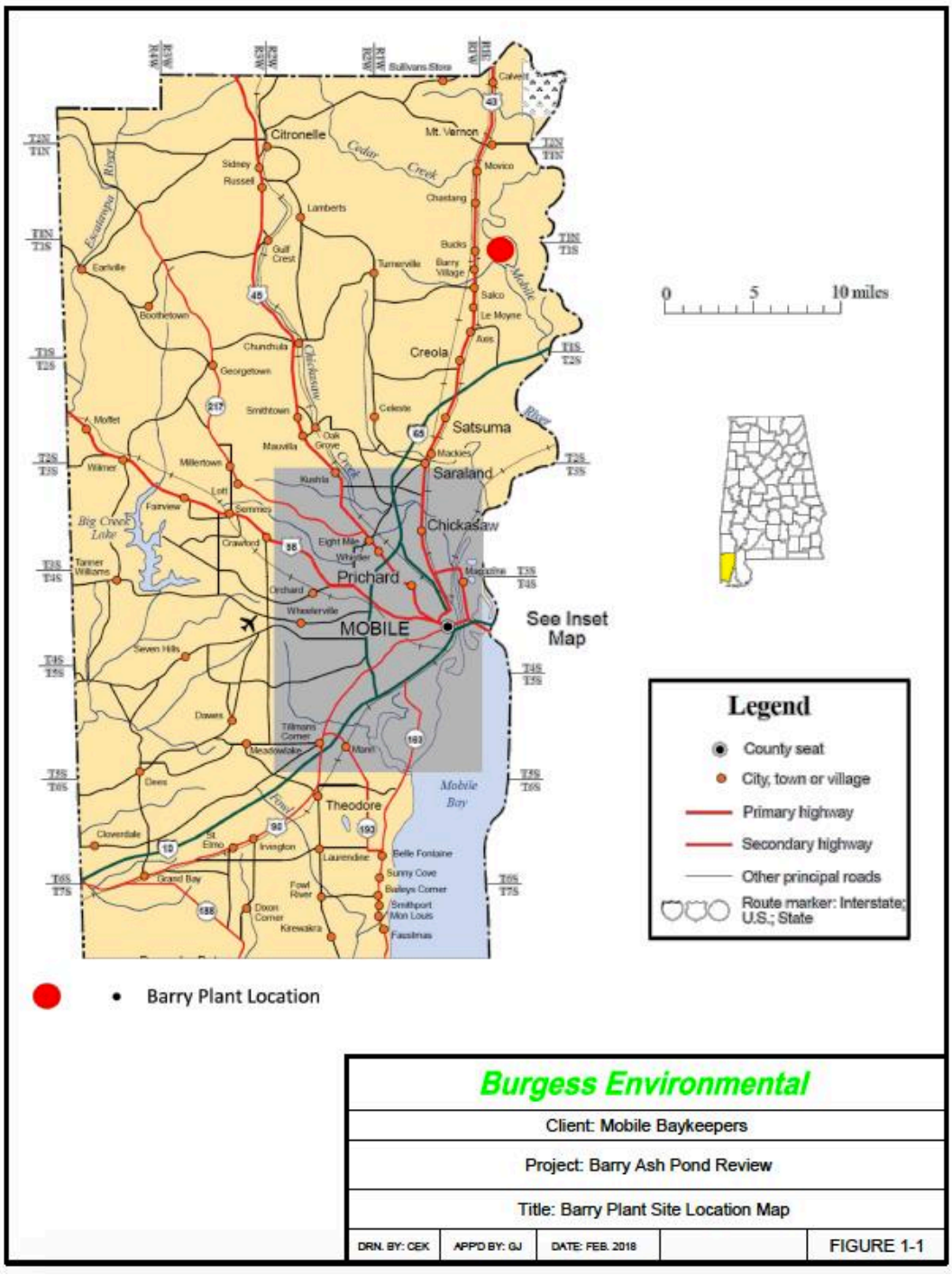
The following documents that were prepared on behalf of the Barry Plant were reviewed to understand the technical basis, composition and stability of the Barry Ash Pond:

- 2015 and 2016 Inspection Reports (by Mickwee and Wilson, P.E.)
- 2017 Annual Groundwater Monitoring and Corrective Action Report
- CCR Fugitive Dust Control Plan (Wyman Turner, P.E.)
- CCR Surface Impoundment Emergency Action Plan (James Pegues, P.E.)
- Closure Plan for Existing CCR Surface Impoundment Barry Ash Pond (James Pegues, P.E.)
- History of Construction for Existing CCR Surface Impoundment Barry Ash Pond (James Pegues, P.E.)
- Inflow Design Flood Control System Plan Barry Ash Pond (James Pegues, P.E.)
- Initial Hazard Potential Assessment Barry Ash Pond (James Pegues, P.E.)
- Initial Safety Factor Assessment Barry Ash Pond (James Pegues, P.E.)
- Initial Structural Stability Assessment Barry Ash Pond (James Pegues, P.E.)
- Liner Design Criteria 40 CFR Part 257.71 Barry Ash Pond (James Pegues, P.E.)

Additional background information pertaining to the Barry Ash Pond was obtained from 'Dam Safety Assessment of CCW Impoundments James M. Barry Electric Generating Plant', a report prepared for the U.S. EPA by O'Brien and Gere (2010). A complete list of references is summarized in Section 7.

**Figure 1-1**

**Barry Plant Location Map**



# 2 SITE DESCRIPTION

## 2.1 Barry Power Generating Facility

The James M. Barry Electric Generating Plant (Plant) is located along the west bank of the Mobile River at 15300 U.S. Highway 43 North, Bucks, Alabama approximately 30 miles north of Mobile, Alabama, and is owned and operated by Alabama Power. In 2010, the Plant operated seven electric generating units; two natural gas-fired combined cycle units and five coal-fired units providing a total generating capacity of 2.66 GW. At the time of writing this report only two of the coal-fired units (4 and 5) were understood to be in operation.

In 2010, Plant Barry produced approximately 400,000 tons of coal combustion waste (CCR) by-products per year. The CCR produced by burning coal was managed on-site within a single impoundment (the Barry Ash Pond) located immediately southeast of the power generating facilities (O'Brien and Gere, 2010). A plan view of Barry Plant development area is presented in Figure 2-1.

Generating Unit #5 is equipped with a flue-gas desulphurization (FGD) scrubber, which reduces pollutants such as sulphur dioxide and nitrous oxide. The primary by-product of the emission scrubbing process is synthetic gypsum, which was also disposed of in the Barry Ash Pond. A Gypsum Collection Basin (GCB) was put into service in late 2010 to contain the synthetic gypsum by-product and is located west of the Barry Ash Pond. Since the GCB was put into service, the decant water (the water left on top of the GCB after solids have mostly settled out) from the GCB is directed through the Barry Ash Pond (O'Brien and Gere, 2010).

## 2.2 Coal Ash Pond

The Barry Ash Pond is located southeast of the power generating complex (Figure 2-1). The pond is bounded to the north by the Plant, to the east and south by the Mobile River, and to the west and southwest by the Plant cooling water discharge canal. Through essentially all of its history the Barry Ash Pond has not been subject to regulatory oversight.

The Barry Ash Pond was reportedly placed into service in 1965 and is approximately 600 acres in size. The total storage capacity of the Barry Ash Pond is approximately 18 million cubic yards and is reported to be over 90% full. These capacity estimates are based on a Closure Plan submitted under Section 257.102 of the Standards (Pegues, 2017). This volume is significantly larger than those calculated by Southern Company Services, a corporate affiliate of Alabama Power Company, and reported by O'Brien and Gere (2010).

Dikes surround the east, south and west edges of the Barry Ash Pond embankments; the west and east embankments appear to tie into natural ground on the north side of the impoundment. The pond was reportedly constructed in 1965 and the dikes expanded on four occasions, in 1972, 1992, 1998, and 2004. Additional dike construction work was in progress at the time of the site visit, which was completed on February 9, 2018. There have been no major modifications to the pond outfall structure. The pond was built on a marsh area and continues to support marsh vegetation, such as cattails and water hyacinths. Portions of the pond extend into Mobile River and the pond was constructed over Sisters Creek and its confluence with the Mobile River.

According to documentation provided to USEPA by Alabama Power, CCR materials contained in the Barry Ash Pond include fly ash, boiler slag, flue gas emission control residuals, and other regulatory-permitted, low volume wastes. Historically, the pond also accepted metal cleaning wastes (Pruner, 1991). These types of wastes can contain elevated concentrations of heavy metals. These materials, including storm water runoff from the Plant, are transferred to the pond via the plant's storm water pump station. Water flows from north to south through the pond and through two bridge openings in the diversion dike near the southeastern end of the pond. Decant water ultimately discharges to the Mobile River through an outfall structure.

The riser portion of the concrete outfall structure is made up of a four-sided, 8-feet square overflow weir. The discharge conduit is a 48-inch diameter corrugated metal pipe (CMP). The outfall structure is protected by a timber debris barrier. The discharge is permitted under NPDES permit number AL0002879.

The Barry Ash Pond is not lined (Pegues[F], 2016).

## 2.3 Pond Dikes

The Pond is divided into the main ash storage area and the decant area downstream of the diversion dike. The crest of the main ash storage area, including the east and west embankments and the diversion dike, is at approximately elevation 24.5 feet above mean sea level (ft asl). The south embankment elevation surrounding the area downstream of the diversion dike is at approximately 21.5 ft asl. The original pond bottom is reported to be at approximately 3.0 ft asl and the original dike walls before the 1998 raise and the construction of the diversion dike were at a slope of approximately 3H:1V (1 foot of vertical rise for every 3 feet of horizontal distance).

The embankment was originally constructed to a top elevation of approximately 18 ftasl. According to the Plant Barry Ash Pond South Dike and Diversion Dike Slope Stability Report (September 2004), in 1992, the east and west embankments were raised three feet to

approximately 21 ftasl. In 1998, the east and west embankments were raised to between approximately 23 and 24.5 ftasl using compacted fill.

A diversion dike was also constructed in 1999 near the south end of the pond to create a decant area prior to discharge through the outlet structure. The diversion dike crest elevation was originally constructed to approximately 18 ftasl and in 2004 was raised to approximately 24.5 ftasl, and the crest of the south embankment was raised to approximately 21.5 ftasl. The side slopes were constructed at approximately 3H:1V.

There have been documented minor repairs over the years such as filling of animal burrows, repairs to shallow slides, regular maintenance and mowing, stump removal at toe of slope, filling and compaction of surface erosion features, and placement of riprap along water's edge at south end of the Pond to help reduce wave action erosion.

The O'Brien and Gere (2010) review of the 1998 Summary Design Report prepared by Synergy Earth Systems, Inc. indicates that the earth fill of the original embankment section varied in soil type and consistency, but generally consists of a mixture of silty and sandy clays, clayey fine sands and sands underlain by a layer of soft organic silts and clays. According to the report, the underlying soils are the naturally existing marsh deposits over which the embankments were constructed.

There are no toe drains or engineered, low-permeability cut-off walls in the embankment, and there is no embankment instrumentation. These are standard features incorporated into the designs of important dikes and dams. Groundwater monitoring is being implemented as required by the Standards and 2017 monitoring results are available to the public.

## 2.4 Surface Geology

**Regional**

Mobile Bay and estuaries along the Gulf of Mexico margin typically originate as incised fluvial valleys that formed during the most recent drop in sea level and were then inundated by the subsequent postglacial sea-level rise. Most of these estuaries have been filling with sediment from fluvial and marine sources. The Mississippi-Alabama shelf province is defined by characteristics resulting from deltaic deposition advancing and receding as the sea level rose and fell (USGS, 2018).

According to the Quaternary Geologic Map of the Mobile $4^{o}$ to $6^{o}$ Quadrangle (USGS, 1988) the Barry Pond is underlain by Alluvial Delta Loam, which is described as inter-bedded yellowish gray to brownish gray, poorly sorted to well sorted, coarse to fine sand, silt and clay of Holocene age. The deposit may include organic muck, lenses of peat, and freshwater marsh deposits. The

deposits within and above the Mobile River estuary are reported to be present to an elevation of 10 ftasl and may exceed 100 ft in thickness. Thinner accumulations are anticipated in the Barry area.

The surface deposits adjacent to and west of (and potentially underlying) the Alluvial Delta Loam deposit consist of Delta Deposits of Miocene and Pleistocene age. Delta Deposits are described as inter-bedded gray to yellowish gray to brownish gray, poorly sorted to well sorted, clay, silt and sand. They may contain zones of peat and marsh deposits of Holocene age. The Delta Deposit thickness is reported to vary between 10 and 30 ft.

**Site Conditions**

Soils underlying the Barry Ash Pond are reported by Alabama Power in their Initial Factor of Safety Analysis Report and by reports issued by ADEM (1994) and the U.S. EPA (Pruner, 1991). Portions of the Pond are underlain by soft clayey marsh deposits and portions are underlain by alluvial sands of Miocene age. These deposits are consistent with the range of soil conditions reported regionally.

Additional insight into the shallow soil conditions underlying the Barry Ash Pond was obtained during the site visit, by inspecting eroded surfaces along the Mobile River adjacent to the pond. These eroded surfaces confirm the site conditions reported above. Portions of the pond appear to be underlain by organic clay marsh deposits and portions of the pond appear to be underlain by both Holocene and pre-Holocene sands.

## 2.5 Hydrogeology

Two major aquifers are reported regionally (ADEM, 2010), the alluvial coastal aquifer, which is of Holocene age, and the Miocene and Pleistocene aquifer, which is reported to be up to 100 feet thick and extends throughout the area of the Mobile River estuary. These aquifers are unconfined, are in hydraulic connection to each other and to surface water, and are viewed as being highly susceptible to contamination because they are hydraulically connected to surface water.

The sandy deposits underlying the Barry Ash Pond are hydraulically connected to the Mobile River and the Miocene and Pleistocene aquifer. The top of the sand deposits and hence the top of the aquifer is coincident with the ground surface and the base of the ash deposit, wherever the clayey organic marsh deposits are not present.

## 2.6 Hydrology

The Mobile River is located in southern Alabama and flows below the confluence of the Tombigbee and Alabama rivers. The Mobile River is approximately 45 miles long and drains an area of 44,000 square miles, which includes Alabama, Mississippi, Georgia, and Tennessee. It is one of the largest stream drainage basins located entirely in the United States and has historically provided the principal navigational access for Alabama.

The Tombigbee and Alabama River join to form the Mobile River approximately 50 miles northeast of Mobile, along the county line between Mobile and Baldwin counties. The combined river flows south, in a winding course. Approximately 6 miles downstream of this confluence, the channel of the river divides, with the Mobile flowing along the western channel. The Tensaw River, a bayou of the Mobile River, flows alongside to the east, separated by approximately 2 to 5 miles. The Mobile River flows through the Mobile-Tensaw River Delta and reaches Mobile Bay on the Gulf of Mexico just east of downtown Mobile

Plant Barry is located within the Big Chippewa Lake watershed, which has a total area of 48,052 acres and is part of the wetland located immediately northeast of the Barry Plant and Mobile River.

Plant water, which includes process water (ash sluice water and low-volume waste) and stormwater from various sumps located within the generating plant, is directed through the Barry Ash Pond.

A cooling water discharge canal is located west side of the Barry Ash Pond. This canal also intercepts water flowing through Sisters Creek, which was a natural stream that was displaced and filled with CCR by the construction of the Barry Ash Pond.

**Figure 2-1**

**Site Plan - Barry Ash Pond**

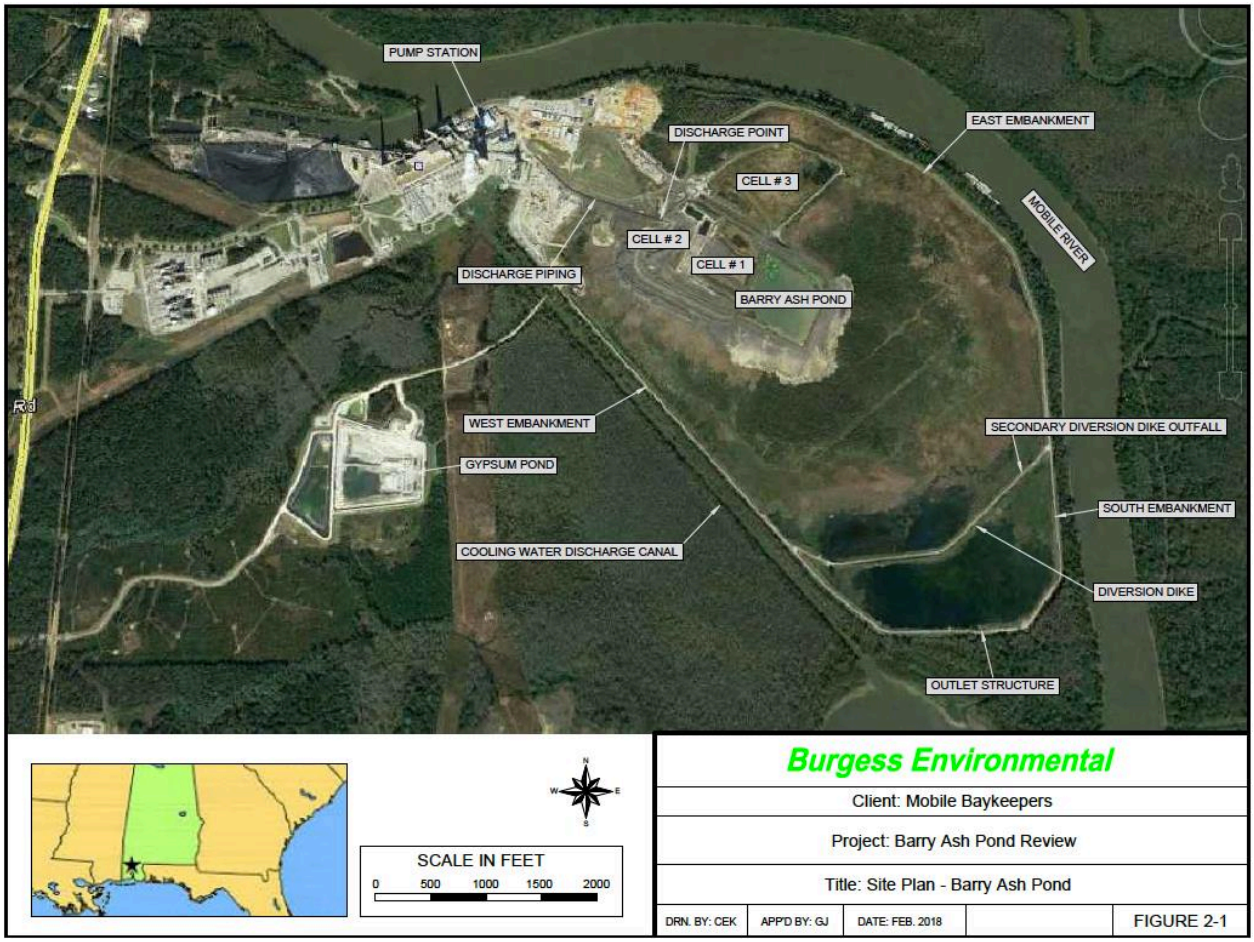


**Figure 2-2**

**Surface Geology**

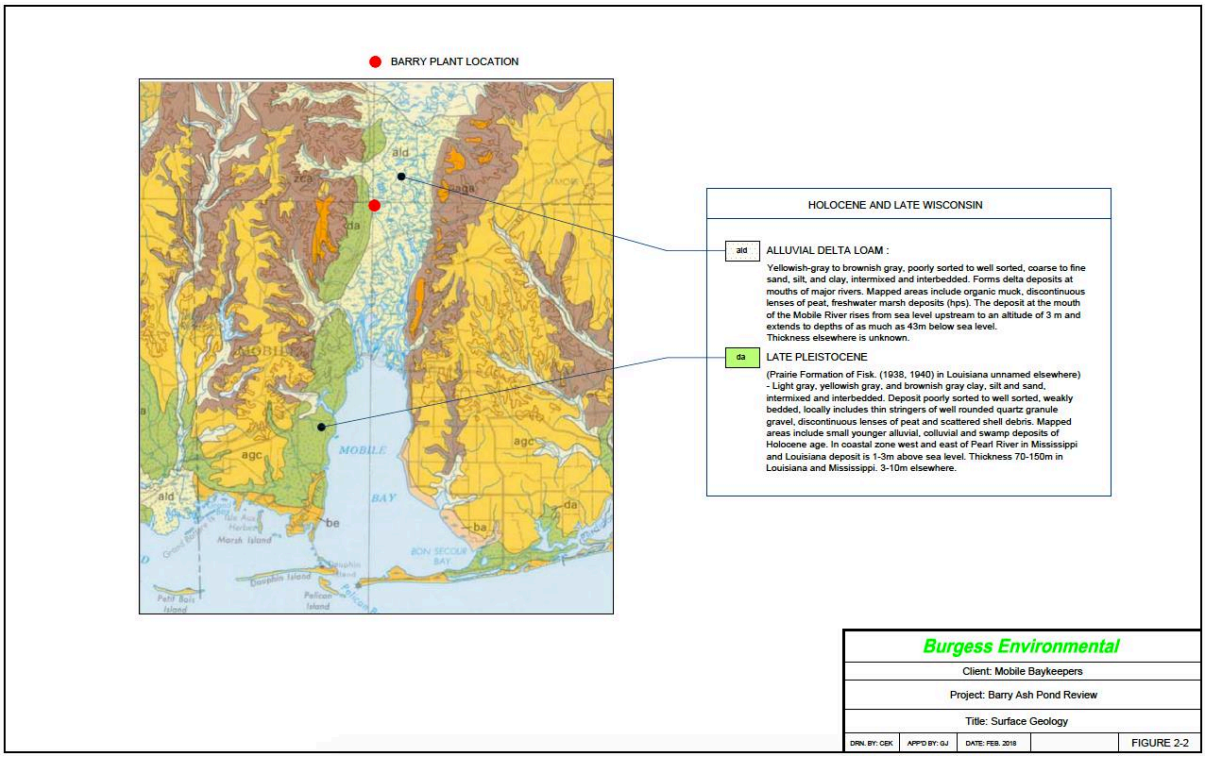
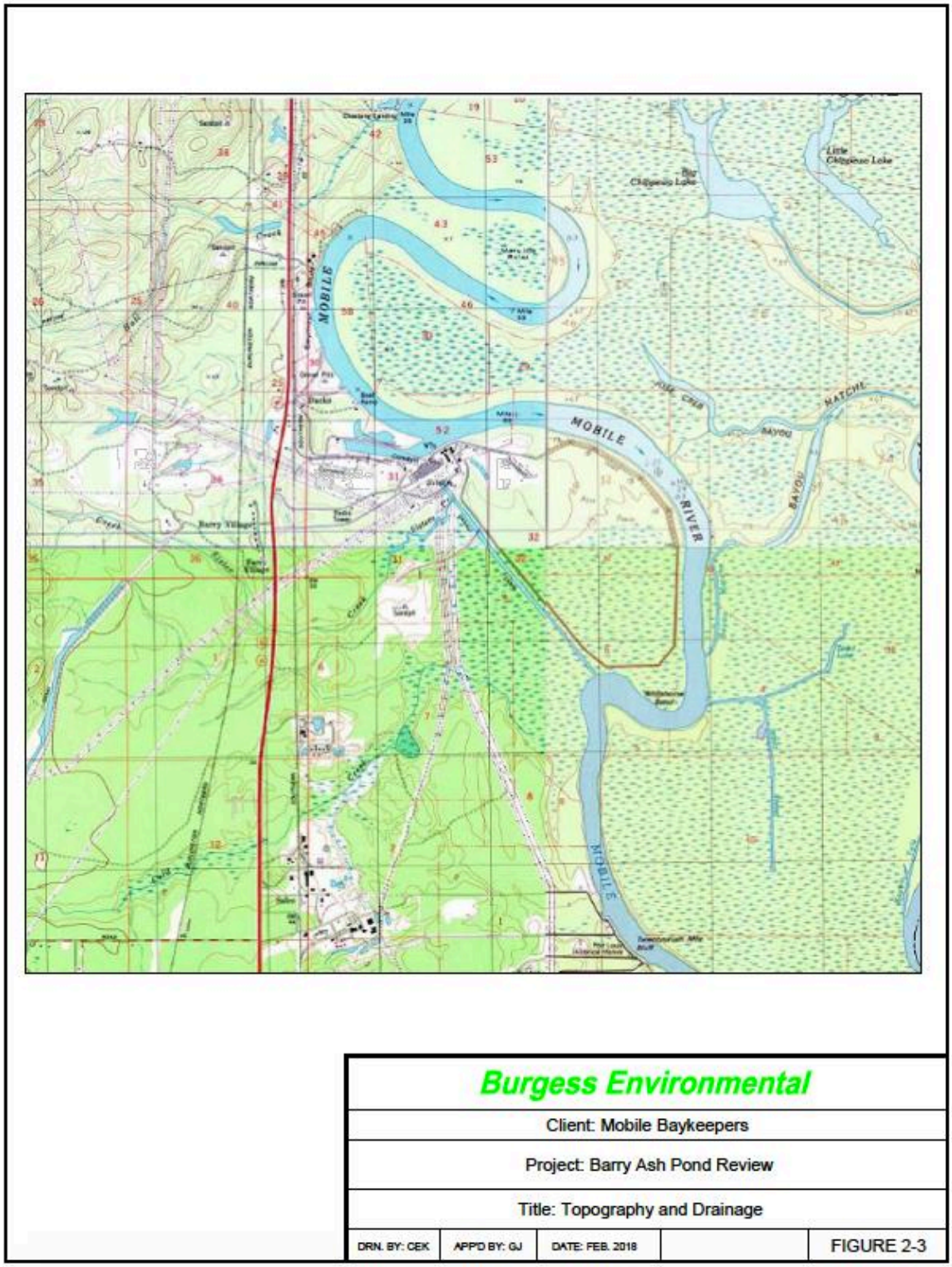


**Figure 2-3**

**Topography and Drainage**



# 3 LEGISLATION

## 3.1 40 CFR Part 257, Subpart D

### General

40 CFR Part 257, Subpart D - Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments (the Standards) was promulgated by the U.S. EPA in response to failures of large CCR impoundments that impacted waters of the United Sates. This legislation is intended to complement existing federal, state and local legislation regarding CCR disposal facilities and environmental protection. This section highlights aspects of these Standards as they may apply to this review of the Barry Ash Pond. Its intent is not to evaluate compliance of the Barry Ash Pond with this legislation. Rather the intent of this section is to highlight technical aspects of the Standards to help guide this review and assessment of the Barry Ash Pond.

The operator of a CCR disposal facility is required to post most of the underlying information, plans and studies on an internet site that is made available to the public. Section 4 provides a summary of the requirements of these Standards together with the status of the Barry Ash Pond based on the reports and studies that have been posted for review.

### Location Restrictions

Location restrictions for CCR impoundments apply to existing CCR surface impoundments. The following restrictions (paraphrased) are most relevant to this review, and the environmental and stability aspects of the Barry Ash Pond:

- Not in direct contact with an underlying aquifer or within 5 feet vertically of a zone that may be inundated by an underlying aquifer.
- Not in a wetland or adjacent to a wetland such that the CCR impoundment may harm that wetland. For existing CCR impoundments the owner must demonstrate a lack of harm to the wetland by October, 2018.
- Not in an area subject to recent faulting, high seismic activity or where the ground is unstable. Stability concerns that may affect the integrity of a CCR surface impoundment include erosion, differential settlement and ground movement.

### Design

The following design standards and guidance apply to new or laterally expanding CCR impoundments (except as otherwise noted):

- a composite liner that comprises a 30 mil plastic and underlying clay-soil liner having a hydraulic conductivity no greater than $10^{-7}$ cm/sec

- a leachate collection system overlying the composite liner
- demonstrated structural integrity (all CCR impoundments above grade), which includes;
    - a hazard assessment
    - emergency action plan
    - assessment of the foundation, composition, contents and capacity of the CCR impoundment
    - stability assessment
    - flood assessment (1 in 1000 years event for impoundment judged to present a 'significant' hazard
    - instrumentation and monitoring programs

**Operating Criteria**

The following operating requirements are specified in the Standards:

- control and minimization of fugitive air emissions, with annual report
- run-on and run-off controls
- inflow flood controls
- inspection and repair/maintenance programs
- groundwater monitoring and corrective action (in place by October, 2017)

**Closure and Post-Closure Care**

The following requirements are included in Closure and Post-Closure Care section of the Standards:

- the impoundment must be stable and secure if the CCR is to be capped and closed in-place
- cap design and specifications are included
- standards for closure by removal
- retro-fitting or closure of the facility is required if groundwater exceedances are observed over a 6-month period
- requirements for planning, implementation and reporting

# 4 ASSESSMENTS

## 4.1 General

Publicly available assessments of the Barry Ash Pond were obtained by Mobile Baykeeper and from the Barry Plant website to assist in this review. These assessments have been grouped into the following subject areas, which are discussed further in underlying subsections:

- stability analyses
- flood and risk assessments
- water quality and environmental
- inspections and maintenance

Most of the assessments were completed by James Pegues a Professional Engineer with the Southern Company, the parent company of Alabama Power Company. A summary of the content and status of these assessments and reports in comparison with the requirements of the EPA Standards is presented in Section 4.9.

## 4.2 Construction

The history of construction of the Barry Ash Pond is summarized by Pegues[a] as required by Section 257.73. The Ash Pond was originally constructed in 1965. The pond was formed with the creation of dikes on the east, south, and west sides of the impoundment. The north side of the impoundment is natural ground that ties into the east and west dikes. The dikes were modified in 1972, 1992, 1998, and 2005. Design and construction information appears to be available for the 1998 and 2005 expansion programs but not for the previous construction programs. Selected drawings and construction specifications are included in the history of construction report (Pegues[a]) but no foundation information is included. No construction quality assurance and quality control data is presented or summarized in this report.

The outlet consists of a vertical pipe riser located in the south end of the Pond, behind a diversion dike that was installed in 1999 and expanded in 2004 to increase residence time and sedimentation within the Pond. Recent minor modifications to outlet structure have been put in place to aid in separation of water and solids, and to increase discharge capacity.

## 4.3 Stability Analyses

An Initial Factor of Safety of the Pond dikes was completed by Pegues[b] in accordance with the requirements of Section 257.73 of the Standards. The assessment utilized commercially available software to analyse slope stability and assumptions for soil conditions and properties

that were obtained from previous reports. The stability analyses were completed for the 'critical section' along the northeast main dike, although the criteria used to establish the critical section was not explained. Liquefaction analysis was not completed because the dikes were determined by Pegues as not susceptible to liquefaction. It is standard practice to consider this potential mode and liquefaction analysis should have been completed for the Barry Pond. In particular, liquefaction analysis should have been completed for the dikes that are founded on ash and sand that could be susceptible liquefaction.

The dikes were constructed primarily on organic clay, which is in turn underlain by alluvial sands. The dikes are reported to be constructed using clay and clay sand, with some bottom and fly ash used in portions of the dike construction. Soil properties used in the analyses are summarized in Table 4.1. The Pond was assumed to be full of bottom and fly ash, and the water level was assumed to coincide with the elevation of the top of the dike. A schematic view of the dike cross-section used in the stability analysis is presented in Figure 4-1.

**Table 4.1**

**Summary of Soil Properties Used in Stability Analyses**

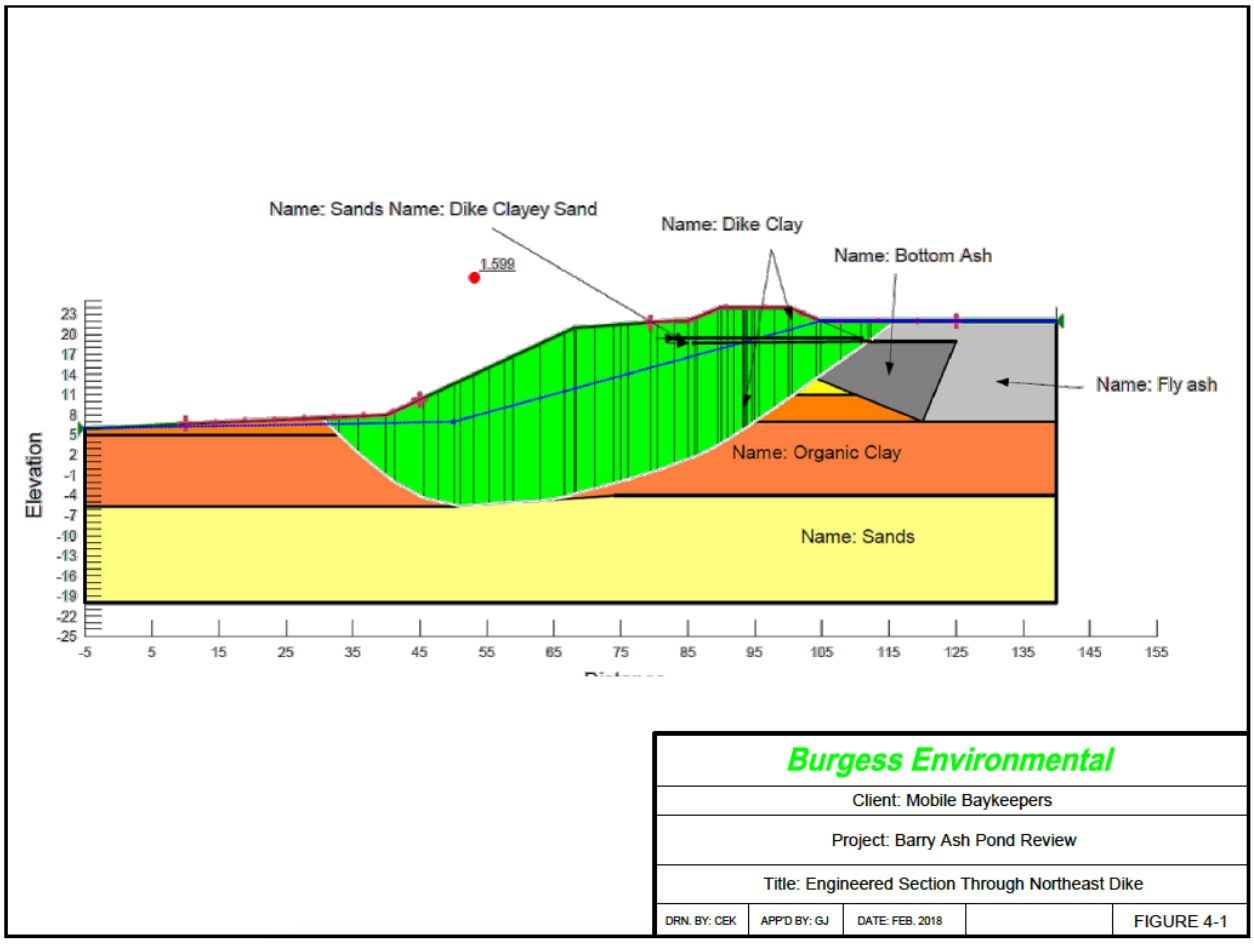
| Soil Properties of North East Main Dike | | | |
|---|---|---|---|
| **Layer** | **Density (pcf)** | **Cohesion (psf)** | **Friction angle (degrees)** |
| Bottom Ash | 95 | 0 | 35 |
| Fly Ash | 90 | 90 | 2 |
| Dike (clayey sand) | 102.9 | 0 | 30 |
| Dike Clay | 102 | 500 | 0 |
| Organic Clay Foundation | 90 | 444 | 0 |
| Sand Foundation | 107 | 0 | 35 |

The calculated factors of safety varied between 1.6 and 1.5 for the normal, maximum pool and seismic cases, which complies with the requirements of the Standards (1.5 to 1.0). The factor of safety calculation represents the ratio of stabilizing to destabilizing forces. The assessment did not include an analysis of settlement and differential settlement, which would appear to be warranted based on the presence of relatively thick organic clay underlying the northeast dike.

An Initial Stability Assessment of the Pond dikes was also completed by Pegues[c] as per Section 257.73 of the Standards. No new analyses were completed as part of this assessment. Mr. Pegues limited this assessment report to qualitative explanations as to why there were not stability concerns. No analysis was completed regarding the potential for settlement and differential settlement and no detailed analysis of the risk of erosion of the external dikes from the outside was provided. No analysis of potential piping failure was provided, even though

there is evidence of potential for piping as discussed in Section 5.4 of this report. Further, Mr. Pegues concluded that there were no risks associated with the dikes because the perimeter dikes were properly compacted. It is not clear how this conclusion was derived given that the early construction activities do not appear to have been supported by proper engineering drawings, construction specifications or QA/QC data.

**Figure 4-1**
**Engineering Section Through Northeast Dike**




## 4.4 Risk and Flood Analyses

An Initial Hazard Potential Assessment of the Barry Ash Pond was completed by Pegues[d] in accordance with the requirements of Section 257.73 of the Standards. Mr. Pegues concluded that the Barry Ash Pond presented a Significant Hazard Potential, which means that failure of the impoundment would result in significant environmental harm but not risks to human life or critical infrastructure. This is the same hazard potential that was determined by O'Brien and Gere (2010).

An Inflow Design Flood Control System Plan for the Barry Ash Pond was completed by Pegues[d] in accordance with the requirements of Section 257.82 of the Standards. The report is not so much a plan but is an assessment of the ability of the Barry Ash Pond to safely convey flows associated with the 1 in 1,000 years, 24-hour rainfall event. Flows that are contained within the Pond and conveyed by the Pond outlet structure consist of rainfall and a minor amount of process water that is directed through the Pond. Calculations were made using the computer program Hydraflow for Hydrographs in Civil 3D.

The 1 in 1,000 years rainfall event was 21.7 inches and was calculated to result in an increase in pond level of 5.6 feet, which would reduce the available freeboard (the difference between the top of the pond water and the top of the dike) to 0.03 feet (a little over ¼ of an inch). The maximum inflows and outflows were calculated to be 5,407 and 223 cfs, respectively.

An inundation analysis and Emergency Action Plan were prepared by Alabama Power in accordance with the requirements of the Section 257.105. The Emergency Action Plan is generic in nature and primarily specifies organization and responsibilities. This Plan includes the inundation analysis, which shows that the entire down-stream portion of Mobile River and the surrounding wetlands will be inundated should the Barry Ash Pond fail. Mobile Bay and the Mobile River estuary are known to be important aquatic environments based on the richness and diversity of the species that inhabit these areas.

## 4.5 Water Quality and Environmental

An attestation was completed by Pegues[f] in accordance with the requirements of Section 257.71 of the Standards stating that the Barry Ash Pond design did not include a liner as is required for new facilities. This is an important consideration given that the location of the pond does not comply with 3 of the location restrictions specified in the Standards.

Groundwater investigation and monitoring was completed in 2016 and 2017, and included installation and sampling of 16 monitoring wells completed in the Miocene aquifer underlying the perimeter of the Barry Ash Pond. This report included statistical analysis of the groundwater data, but not any meaningful assessment of water quality and the related impacts to the surrounding environment. For example, not samples were collected from and no comparisons were made to the process water within the pond and the water in Mobile River immediately adjacent to the pond. These comparisons need to be made to determine the nature of the potential impacts to groundwater quality and the potential affects that this water may have on the surrounding environment. In addition, no assessment of potential regulatory standards and their basis was provided in the report. Finally, water quality results are compared to 'background' samples that were collected in 3 of the 16 monitoring wells that were collected

from up-gradient wells. In my opinion, there are no well installations that are representative of background conditions because the water level within the Barry Ash Pond is significantly higher than the water levels measured in the all of the monitoring wells; hence, process water has the potential to seep into all of the monitoring wells.

In early 2018, ADEM fined Plant Barry and the Alabama Power Company $250,000.00 for polluting the groundwater underlying the Barry Ash Pond. This fine was presumably issued based on the results of the groundwater monitoring results recently posted by Plant Barry. It indicates that contamination from the Barry Ash Pond is seeping into the underlying regional aquifer.

## 4.6 Inspections and Maintenance

Richard Mickwee completed the annual inspection and report for the Barry Ash Pond in 2015, in accordance with Section 257.83 of the Standards, and Mr. Wilson performed the same inspection in 2016. These inspection reports are essentially a checklist that reports volumes and water levels. There is no volunteered information and there is no comment on the state of the perimeter dikes or discharge infrastructure. There is no description of maintenance or repair activities that may have occurred or why. A simple statement questioning if any issues that might affect the integrity of the impoundment was simply answered 'no'.

The O'Brien and Gere (2010) independent assessment of the Barry Ash Pond does go into considerably more detail regarding the inspection and maintenance program being implemented for the Barry Ash Pond and recommends that it be continued diligently.

## 4.7 Closure Planning

The Closure Plan submitted by Alabama Power as per Section 257.102 of the Standards (Pegues[8]) contemplates closure of the CCR in place by consolidating the CCR to form the desired grades and capping the area in accordance with the minimum requirements of the Standards (an 18-inch thick infiltration layer overlain by a 6-inch thick topsoil layer). The Closure Plan is very brief and satisfies the minimum reporting requirements of the Standards. No drawings or material specifications are included with the Plan. No discussion is provided regarding erosion protection along the Mobile River or the significant challenges associated with capping a CCR impoundment immediately adjacent to a major waterway and wetland. This report states that of the Barry Ash Pond is expected to be initiated in 2019.

## 4.8 Independent Assessments

Dam Safety Assessment of CCW Impoundments James M. Barry Electric Generating Plant was completed in 2010 by O'Brien and Gere, on behalf of the U.S. EPA, 2010. This assessment was reportedly commissioned by the U.S. EPA in response to significant failures that occurred in the U.S. The reported objective of this work was to provide a Dam Safety Assessment of the Barry Ash Pond, which included the following tasks:

- identify conditions that could adversely affect structural stability or functionality
- note the extent of deterioration, status of maintenance, and need for repair
- evaluate conformity with current design and construction practices
- determine the hazard potential classification

The scope of the O'Brien & Gere assessment that was reported to include the following tasks:

- review pertinent records (prior inspections, engineering reports, drawings, etc.)
- visit and inspect the Barry Ash Pond
- evaluate the adequacy of the outlet works, structural stability, quality and inspection, maintenance, and operations procedures
- identify critical infrastructure within 5 miles down gradient of management units
- evaluate the risks and effects of flood loading on the management units
- identify all leaks, spills, or releases within the last 5 years
- report the findings and conclusions regarding safety and structural integrity

No independent analyses were completed by O'Brien and Gere. The assessment primarily consisted of review of the various reports and studies that were made available to the review team. The assessment concluded that the risk associated with the Barry Ash Pond was significant as the facility is located immediately adjacent to the Mobile River.

Erosion and deterioration of the slopes exposed to the Mobile River were noted, as were holes associated with burrowing and rooting animals. The assessment concluded that the work completed for the Barry Ash Pond was acceptable. Numerous recommendations were made regarding inspections and maintenance. It was noted that there is no instrumentation of the Barry Ash Pond and that it was not possible to identify dike seepage because the dike abuts the Mobile River.

## 4.9 Assessment of Alabama Power Reports

Table 4.2 summarizes the scope and content of the reports prepared by the Barry Plant relative to the requirements of the Standards and generally accepted practices for dam safety. Particular concerns include the following:

- The Initial Stability Assessment report does not consider erosion or differential settlement. These are stability concerns specifically referenced in the Standards. The variable nature of the foundation (soft organic clays inter-bedded with alluvial sands) suggests that differential settlement may be a particular concern for the Barry Ash Pond. Erosion is clearly a concern given that the Barry Pond is essentially in the Mobile River, a vast water course that is susceptible to flooding and is eroding the river bank adjacent to the Barry Ash Pond.
- The Initial Stability Assessment report and the Inspection reports do not make reference to potential piping even though this was a specific concern raised by the O'Brien & Gere report (2010). This is particularly important given the lack of records for initial dike construction.
- The Closure Plan assumes that closure by capping in place is feasible and appropriate even though no analysis is provided to support closure in place. The lack of technical support for this assumption is particularly troubling given that the Barry Pond site does not comply with three of the five location restrictions specified in the Standards.
- The groundwater monitoring report does not include a meaningful technical assessment of water quality and the potential for impact to Mobile River and associated wetland.

**Table 4.2**

**Summary of Status of Standards Requirements**

| Requirement | Section of Standards | Status | Comment |
|---|---|---|---|
| Hazard Potential Classification | 257.73 | Completed | Hazard potential determined to be significant. I agree with this determination. |
| Emergency Action Plan | 257.73 | Completed | Quite generic in nature. No specific actions are noted or contemplated to assist responders. |
| History of Construction | 257.73 | Completed | No design or construction records are available for the early stages of construction. |
| Structural Stability Assessment | 257.73 | Completed | Erosion, differential settlement and potential for piping failure not considered. |
| Factor of Safety Assessment | 257.73 | Completed | Liquefaction failure not analyzed even though portions of the dikes are founded on ash. |
| Fugitive Dust Control Plan | 257.80 | Completed | Not relevant to dam safety, ash slurries are typically not prone to fugitive dust. |
| Flood Analysis | 257.82 | Completed | Very little margin predicted by the analysis. Partial blockage of the outlet would impede drainage. |
| Inspection Reports | 257.83 | Completed | Very brief. Reports don't describe maintenance, which we know was done on occasion. |
| Groundwater Monitoring & Corrective Action | 257.90 | Completed | 2017 Groundwater Monitoring Report is in place. Plant Barry was fined by ADEM for groundwater contamination in 2018. |
| Closure Plan | 257.102 | Completed | It is presumed that closure in place will be allowed. No technical support provided. |
| Publicly Available Internet | 257.107 | Completed | The internet site is established. Many assessments are incomplete or overly simplistic. |

# 5 EVALUATION

## 5.1 General

One of the very striking aspects of this review is the degree to which Alabama Power and the Southern Company have relied on their own people and assessments to review and validate the integrity of the Barry Ash Pond. While this is consistent with the Standard, it is more typical for an organization to contract out an independent third party to assess critical dam structures with such significant hazard risk, and to ensure that individuals possessing the requisite qualifications complete these assessments. The individuals within the Southern Company that completed the assessments may have the requisite qualifications; this is not clear from the reports that were made available by the Barry Plant.

The simplicity of the assessments is also striking, which may reflect the scope of information that the Southern Company decided to include in the reports or the rigor of the assessments. It is more typical to report more rigorous and comprehensive analyses when assessing the integrity of such an important structure.

It is also unusual for such a large impoundment, in such an environmentally important area, not to be supported by instrumentation. It is common for impoundments of this size to include instrumentation such as slope indicators, settlements gauges, monitoring wells and pressure transducers to confirm the performance predictions and design assumptions included in the stability and factor of safety assessments.

## 5.2 Barry Pond Location

The location of the Barry Ash Pond is a critical issue that needs to be evaluated. The Barry Ash Pond location does not comply with at three of five location restrictions specified in the Standards, as follows.

- It is located directly over permeable sands that are hydraulically connected to Mobile River and over regionally important aquifers: the alluvial coastal aquifer, which is of Holocene age; and, the Miocene and Pleistocene aquifer, which is reported to be up to 100 feet thick and extends throughout the area of the Mobile River estuary. These aquifers have been impacted by the pond.
- It was constructed within a regionally important wetland and adjacent to a regionally important river. The area is an important wildlife, wetland and aquatic habitat, and is susceptible to flooding. The downstream Mobile Bay is known to be one of the most biologically diverse aquatic ecosystems in the United States.

- The area and foundation are potentially unstable. The Barry Ash Pond is located adjacent to a meandering river and within its floodplain. The perimeter dikes are susceptible to both river and wave erosion during flooding events, and the foundation soils are susceptible to differential settlement.

Based on the above, it is not appropriate to continue to fill the Barry Ash Pond or to close it in-place without implementing measures that ensure the long-term integrity of the structure. Given the size of Mobile River and its tendency to meander it will be very difficult to guarantee the integrity of the closed ash pond in perpetuity. Further, monitoring and maintenance of the closure will be required long into the future and essentially in perpetuity should the pond be closed in place. These measures are critical given the ecological importance of the Mobile River estuary.

## 5.3 Facility Risk

The risk associated with the Barry Ash Pond is 'significant' in accordance with the criteria of the Standards. Failure of the Pond would result in very significant environmental impact to the adjacent Mobile River as well as downstream aquatic environs. There is not a significant risk of damage to critical municipal infrastructure, nor is there any significant risk of loss of human life were a dike to fail.

## 5.4 Stability

The stability assessment completed by Southern Company does not comply with the requirements of the Standards because it did not consider erosion, differential settlement or potential piping failure of the dikes. The following aspects are considered to be significant stability concerns for the Barry Ash Pond.

**Differential Settlement**

At least a portion of the dikes are founded on organic clay deposits associated with the wetlands that were filled over to construct the Barry Ash Pond. These materials are susceptible to settlement and differential settlement, particularly if they vary in thickness and are inter-bedded with sand deposits that are not susceptible to settlement. Settlement is an important consideration because it can cause cracking and piping failure of the dikes. The anticipated settlement and potential for differential settlement can only be determined by extensive investigations, laboratory testing and geotechnical analyses, which do not appear to have been completed for the Barry Ash Pond. The investigation data pertaining to the pond is not included in the information that has been made available by the Plant.

**Piping Failure**

Piping failure refers to the gradual erosion of an impoundment dike caused by seepage through that dike and does not appear to have been considered by the Southern Company in its assessments or in its inspection reports. This is a particularly important consideration given that there is little or no design and construction information pertaining to the initial stages of construction of the Barry Ash Pond. It is an important failure mechanism that needs to be considered when evaluating earth-filled dams and was specifically identified as a risk by the O'Brien & Gere (2010) assessment completed for the U.S. EPA.

Potential for piping was observed during the site visit completed on February 9, 2018, from a backwater that is located immediately upstream of the outlet structure. A bulge in the toe of the slope is evident at this location, as are slope repairs and accumulation of sand at the toe of the slope. These observations corroborate observations made and pictures taken by Baykeeper staff on February 4, 2016 (see Photos 1 and 2). Evidence of piping can be seen in the slope above and below areas of the slope where sod was placed as part of a slope repair. A short video taken that same day clearly shows seepage flowing out of the toe of the dike, resulting in erosion of the toe.

**Liquefaction Failure**

Some failure risks and modes were not considered or not reported in the assessments completed by Southern Company. For example, liquefaction failure was discounted as a potential failure mechanism in the Initial Factor of Safety Assessment (Pegues[b]). Liquefaction refers to the loss of strength and failure of an embankment that is caused by rising pore pressures induced by dike strain. This is a questionable assumption given that a large portion of the dike construction appears to lack design and construction information, and that at least portions of the dikes are founded on bottom ash, which may be in a loose state that is susceptible to liquefaction.

**External Erosion**

The stability assessment does not consider the potential for erosion to undermine the integrity of the dikes, even though this stability concern is specifically referenced in the Standards. This is a particularly important consideration given that the Barry Ash Pond is located immediately adjacent to the Mobile River.

Erosion can occur two ways, as erosion of the river embankment and dike foundation soils, and as wave erosion during periods of flooding. Both can result in failure of the dikes. River erosion, as shown in Figure 3, is an ongoing process that results in meandering of a river through its floodplain. Bank erosion is clearly evident along the west bank of Mobile River. Over time, this

process and meandering of the river will infringe on the Barry Ash Pond unless significant measures are implemented to prevent this process from occurring.

Wave induced erosion can occur during flood events when the dikes surrounding the Barry Ash Pond are inundated by the flood-waters of the Mobile River. Figure 4 shows the Barry Ash Pond and river flood water near the pond outlet on February 3, 2016 and confirms that flood waters inundate the dikes during these periods (a typical but not an extreme flood event). Wave erosion can occur during these events and can erode the dikes of the Pond.

## 5.5 Flood Related Risks

The flood risk assessment that evaluated the 1 in 1,000 years, 24-hour rainfall event concluded that the resulting water level within the Barry Ash Pond would rise to less than half an inch of the top of the dike. This is a razor-thin margin of error, which can be easily affected by debris getting stuck in the outfall, damage to the outfall or internal wave erosion that is likely to accompany an extreme rainfall event.

The water level within the pond rose to within a few feet of the top of the dikes on February 3, 2016. This event occurred in response to approximately 4 inches of rainfall that occurred over the week prior to the photo being taken according to rainfall records published for Mobile airport that is located south of the Barry Plant. This is significantly less than the 1 in 1,000 years, 24 hour rainfall event (21.7 inches). Photo 4 in Appendix A shows how significant the potential for flooding is, even for events that are less significant than the 1 in 1,000 years design event.

## 5.6 Water Quality

Groundwater monitoring and the associated fine levied by ADEM (2018) indicate that the Barry Ash Pond has resulted in pollution of the underlying Miocene aquifer by arsenic. This monitoring program and associated report did not address or even mention the potential for direct seepage of these contaminants into Mobile River.

The Barry Ash Pond is constructed over an ‘aquifer’ as defined by Section 257.60 (ADEM, 2010). The Barry Ash Pond is also not lined. Given its location within an important and sensitive environment and the presence of sand zones at or near the surface, the rate of process water seepage into the ground and into the Mobile River is expected to be significant. Groundwater seepage through the ash pond and into Mobile River will continue even if the ash pond is capped and closed in place because precipitation will continue to seep through the cap and groundwater will continue to seep through the waste.

## 5.7 Pond Closure

The Closure Plan for the Barry Ash Pond contemplates capping the CCR in-place and in accordance with the minimum cap requirements included in the Standards. The wisdom of closing the Barry Ash Pond in its current location should be re-evaluated because the location does not comply with 3 of the 5 location restrictions included in the Standards. The Mobile River will eventually meander through the Barry Ash Pond unless significant erosion protection measures are implemented to prevent this from occurring. Such measures would alter the natural environment of the riparian and wetland habitat along this portion of the river. They would also require monitoring and maintenance essentially in perpetuity to ensure that erosion and river meandering does not erode the contents of the ash pond into the Mobile River. It will be very difficult to ensure that these measures are implemented and effective over such a long time frame.

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# 7 CLOSURE

This report has been prepared for Mobile Baykeeper. The text contained herein presents documentation of the review and site inspections of the Barry Ash Pond associated with the Barry Power Generating Facility that is located near Mobile, Alabama. This represents the opinion of Burgess Environmental Ltd. that is based on this work as well as information provided by the Mobile Baykeeper and publicly available information that has not been independently verified.

All information contained herein has been reviewed and interpreted by, or under the direct supervision of Gordon J. Johnson, P.Eng.

Gordon J. Johnson, M.Sc., P. Eng.
President
Burgess Environmental Ltd.

# APPENDIX A
# SITE PHOTOGRAPHS

**Photo 1: Evidence of Piping North of Pond Outlet (Feb. 4, 2016)**

**Photo 2: Evidence of Piping North of Pond Outlet (Feb. 4, 2016)**

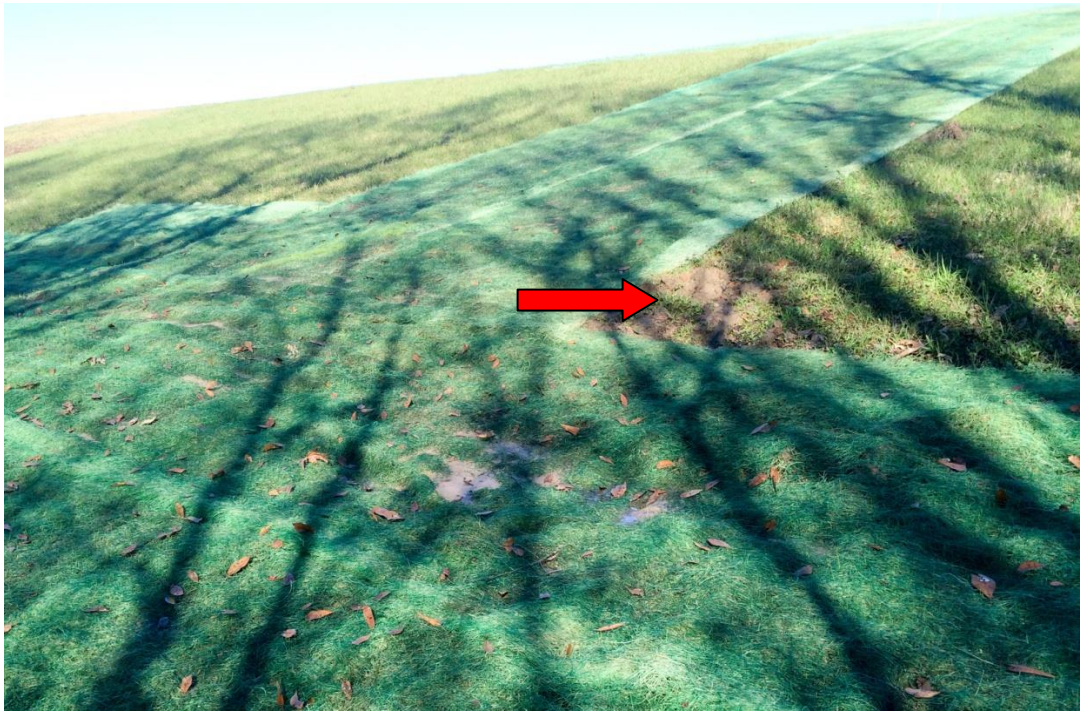

**Photo 3: Evidence of River Bank Erosion (Feb. 9, 2017)**

**Photo 4: Flooding Adjacent to Barry Ash Pond (Jan. 3, 2016)**